Long-term evolution of organic matter modified by cultural practices in a cultivated Acrisol - consequences on soil organic carbon stocks

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Context

►Under Sudano-Sahelian climatic conditions, the level of soil organic carbon (SOC) is a critical, if not vital, component of fertility. Given the low nutrient status and the drought constraint, the level of soil organic matter is a key factor to ensure sustainable plant productivity.

►The aim of our research was to evaluate the stocks of SOC in a ferric Acrisol of Burkina Faso under different farming systems including manuring and crop residues restitution to the soil. The fractionation of soil organic matter (SOM) allowed us to assess the degree of SOM protection.

Materials and methods

This study has used samples and results from some plots of the long-term experiment of Saria (Burkina Faso) settled in 1960 (Sedogo, 1993).

Treatments differed in the rates of mineral fertilization, level and nature (sorghum straw, farm manure (Man.) of organic restitutions application and the tillage practices (scrapping and ploughing) under a continuous sorghum crop since 1960.

Soil is a ferric Acrisol, mean annual temperature is 28.0°C and mean annual precipitation 800 mm. The duration of soil moisture deficit is 8 to 9 months.

Measurements and observations concerned: (i) in the field the soil morphological characterization, bulk density and crops yields, (ii) in the laboratory the organic matter (OM) characterization (biochemical composition) and soil C, N, and particle-size fractionation.

The model RothC 26.3 (Coleman and Jenkinson, 1999) was run to check predicted values with measured SOC stocks for the different treatments.

Results

Plant Yield and S O C content

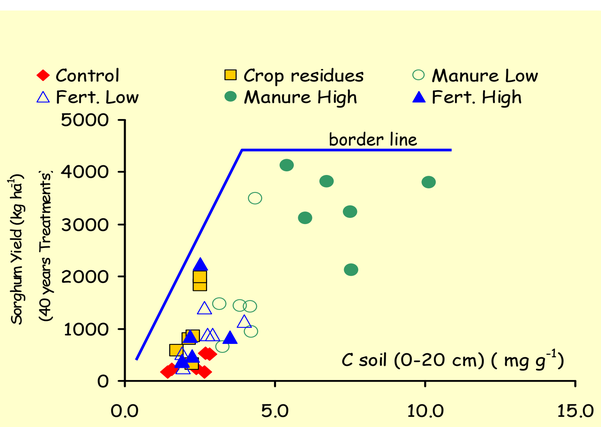


***Fig1** : Improving SOC budget with High manure application increases sorghum yield (limit value ~ 6.0 mgC g^{-1}) → Agronomic and environmental goals are in accordance*

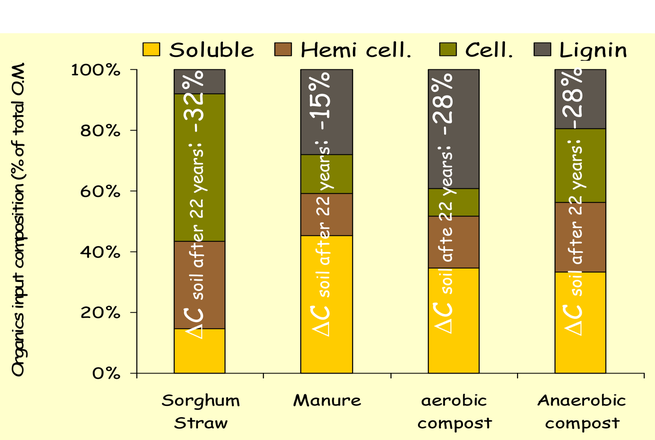
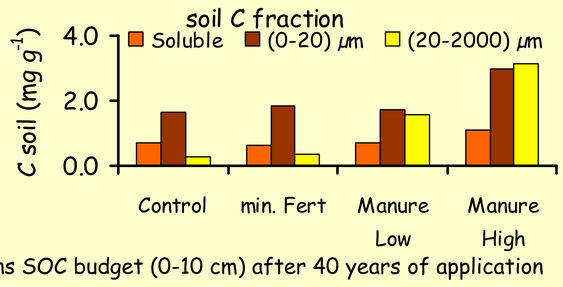


***Fig2** : 22 years cultivation → general losses of SOC from the 20 first cms of soil stock (Control -44%) , restricted by organic inputs, specially animal manure.*

After 10 years of application, soil tillage **does not affect SOC stock** on first 40 cm layer and this, with or without manure input. Futhermore, **soil tillage is beneficial** for the crop.

"Quality" of SOC stock induced by O M inputs



Fractions SOC budget (0-10 cm) after 40 years of application

***Fig 3a** : High level manure improve C storage in (0-20 µm) fraction that is protected to the mineralization.*

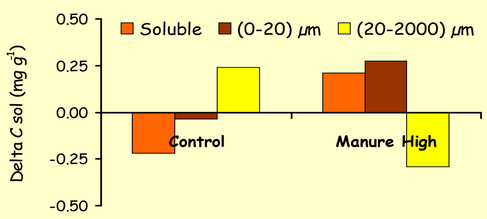


***Fig 3b** : Nitrogen fertilizer effect (urea) is reversed in case of manure input at high level. C storage in the fraction < 20 µm is improved .*

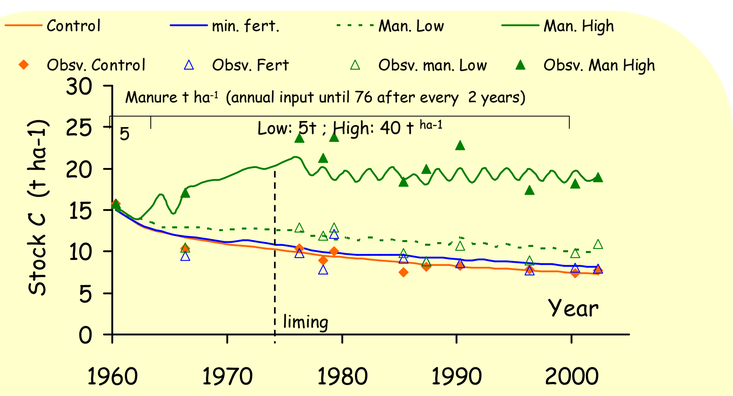


***Fig 4** : RothC modelization of SOC stock between 1960 and 2000 shows that the high level manure only is able to store carbon in the soil. However it's necessary to apply an attenuation coefficient of 0.34 to fit observed and calculated values. Soil macrofauna activity (termites) and manure characteristics may explain this.*

✓Half-life of "labile" SOC is about 17 years (Soil fractions decomposition rate simulation).

Conclusions

Increasing the storage of C in the soil is possible with the current farming practices but their optimisation has to be achieved. This study opens onto possible actions and concludes on the necessity to take into account the macrofauna and microbial activities in interaction with the organic matter for a better control of the organic flows.

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